source: https://doi.org/10.7892/boris.118179 | downloaded: 6.5.2023

EGSIEM

European Gravity Service for Improved Emergency Management

The EGSIEM combination service for monthly gravity fields

U. Meyer[1], Y. Jean[1], D. Arnold[1] , A. Jäggi[1] and the EGSIEM-ACs[2,3,4]

[1] Astronomical Institute, University of Bern

[2] Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences

[3] Institute for Theoretical and Satellite Geodesy, TU Graz

[4] Groupe de Recherche de Géodésie Spatiale, Toulouse

IAG Workshop

Satellite Geodesy for Climate Studies

Bonn, Germany

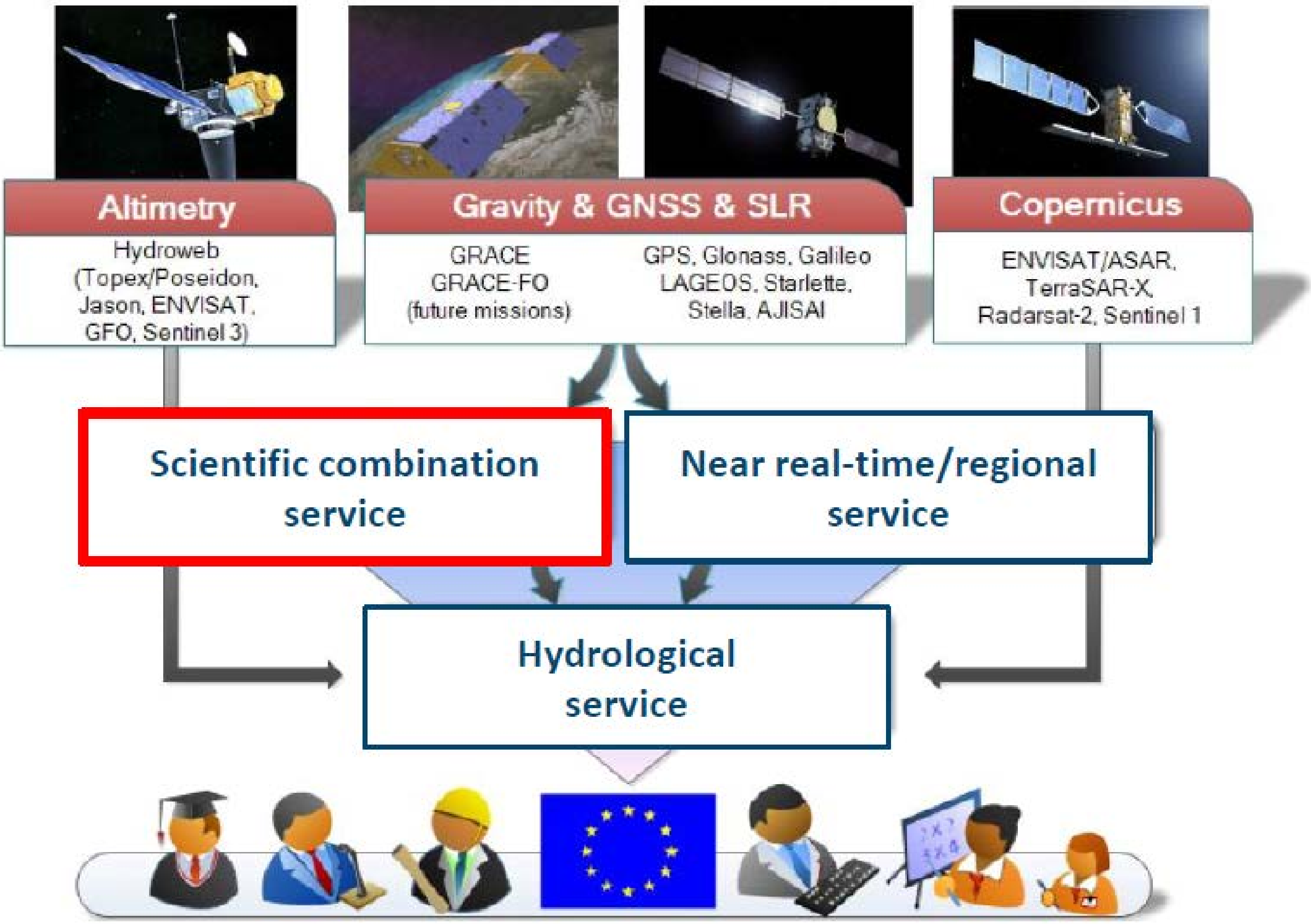
September 19-21, 2017

UNIVERSITÄT BERN · UNIVERSITÉ DU LUXEMBOURG · GFZ Helmholtz Centre Potsdam · TU Graz Graz University of Technology · Leibniz Universität Hannover · cnes · DLR · géode&cie · Horizon2020

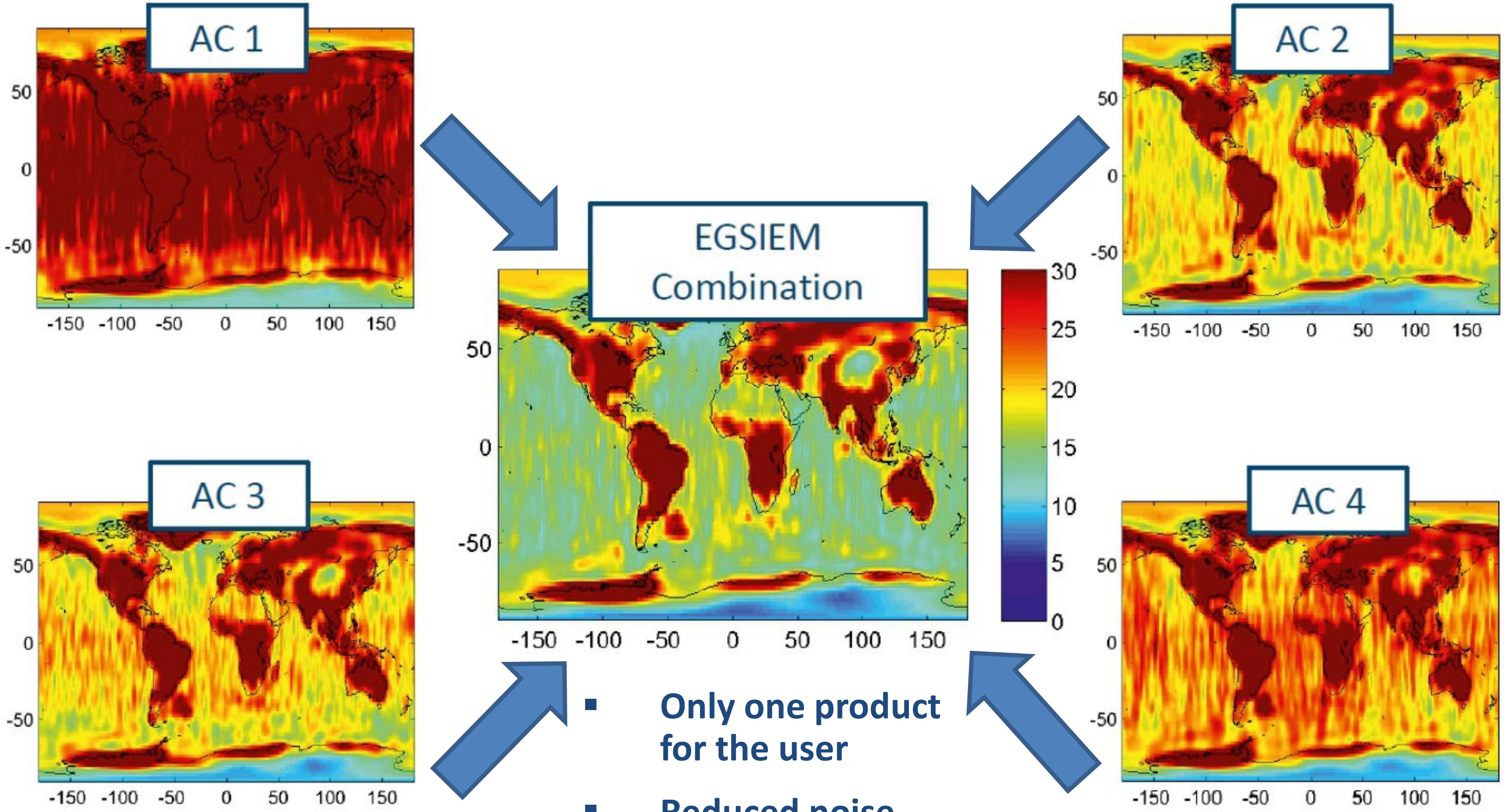
Contents

- The EGSIEM project
- The Scientific Combination Service
- Gravity Field Determination
- The EGSIEM plotter
- User-friendly L3-Products
- Transition to IAG service COST-G

EGSIEM Project – Three services are established



Scientific Combination Service



- Only one product for the user
- Reduced noise

Scientific Combination Service

- The EGSIEM combination service provides monthly GRACE K-band gravity fields combined on solution / normal equation (NEQ) Level.
- To ensure consistency, a set of common standards for reference frame, Earth rotation, force model and satellite geometry were defined.

Why combine results based on the same observations?

Errors in GRACE monthly gravity fields are still dominated by analysis and background model noise, not observation noise => AC-specific errors are reduced by combination!

Linear observation equations:

$$\boldsymbol{l} = \boldsymbol{A}\boldsymbol{p} + \boldsymbol{\epsilon}$$

Weight matrix:

$$\boldsymbol{P} = \boldsymbol{C}_{ll}^{-1}$$

Solution (least-squares):

$$\boldsymbol{p} = (\boldsymbol{A}^T \boldsymbol{P} \boldsymbol{A})^{-1} \boldsymbol{A}^T \boldsymbol{P} \boldsymbol{l}$$

Linear observation equations:

$$\boldsymbol{l} = \boldsymbol{A}\boldsymbol{p} + \boldsymbol{\epsilon}$$

Observations

Weight matrix:

$$\boldsymbol{P} = \boldsymbol{C}_{ll}^{-1}$$

Solution (least-squares):

$$\boldsymbol{p} = (\boldsymbol{A}^T\boldsymbol{P}\boldsymbol{A})^{-1}\boldsymbol{A}^T\boldsymbol{P}\boldsymbol{l}$$

Linear observation equations:

$$\boldsymbol{l} = \boldsymbol{A}\boldsymbol{p} + \boldsymbol{\epsilon}$$

Observations

unknown Parameters

Weight matrix:

$$\boldsymbol{P} = \boldsymbol{C}_{ll}^{-1}$$

Solution (least-squares):

$$\boldsymbol{p} = (\boldsymbol{A}^T\boldsymbol{P}\boldsymbol{A})^{-1}\boldsymbol{A}^T\boldsymbol{P}\boldsymbol{l}$$

Linear observation equations:

$$\boldsymbol{l} = \boldsymbol{A}\boldsymbol{p} + \epsilon$$

Observations

Weight matrix:

unknown Parameters

$$\boldsymbol{P} = \boldsymbol{C}_{ll}^{-1}$$

Observation Errors

Solution (least-squares):

Designmatrix

$$\boldsymbol{p} = (\boldsymbol{A}^T\boldsymbol{P}\boldsymbol{A})^{-1}\boldsymbol{A}^T\boldsymbol{P}\boldsymbol{l}$$

Non-linear case:

$$\boldsymbol{A} = f(\boldsymbol{p})$$

A priori:

$$\boldsymbol{l}_0 = \boldsymbol{A}_0 \boldsymbol{p}_0$$

Corrections (least-squares):

$$\Delta \boldsymbol{p} = (\boldsymbol{A}_0^T \boldsymbol{P} \boldsymbol{A}_0)^{-1} \boldsymbol{A}_0^T \boldsymbol{P} (\boldsymbol{l} - \boldsymbol{l}_0)$$

Noise Model: Variance-Covariance

$$C_{ll} = \begin{pmatrix} \sigma^2_{l_1} & \sigma_{l_1 l_2} & \cdots & \sigma_{l_1 l_n} \\ \sigma_{l_2 l_1} & \sigma^2_{l_2} & \cdots & \sigma_{l_2 l_n} \\ \vdots & & \ddots & \vdots \\ \sigma_{l_n l_1} & \sigma_{l_n l_2} & \cdots & \sigma^2_{l_n} \end{pmatrix}$$

Noise Model: Variance-Covariance

Variance information

$$C_{ll} = \begin{pmatrix} \sigma_{l_1}^2 & \sigma_{l_1 l_2} & \cdots & \sigma_{l_1 l_n} \\ \sigma_{l_2 l_1} & \sigma_{l_2}^2 & \cdots & \sigma_{l_2 l_n} \\ \vdots & & \ddots & \vdots \\ \sigma_{l_n l_1} & \sigma_{l_n l_2} & \cdots & \sigma_{l_n}^2 \end{pmatrix}$$

Noise Model: Variance-Covariance

Variance information

$$C_{ll} = \begin{pmatrix} \sigma_{l_1}^2 & \sigma_{l_1 l_2} & \cdots & \sigma_{l_1 l_n} \\ \sigma_{l_2 l_1} & \sigma_{l_2}^2 & \cdots & \sigma_{l_2 l_n} \\ \vdots & & \ddots & \vdots \\ \sigma_{l_n l_1} & \sigma_{l_n l_2} & \cdots & \sigma_{l_n}^2 \end{pmatrix}$$

Covariance information: correlations

Problems

Simplified error model:

$$C_{ll_0} = \begin{pmatrix} \sigma^2_{\mathrm{GPS}} & & 0 \\ & \ddots & \\ 0 & & \sigma^2_{\mathrm{KBR}} \end{pmatrix}$$

Separate estimation (regularization):

$$\begin{pmatrix} \Delta \boldsymbol{p}_o \\ \Delta \boldsymbol{p}_g \end{pmatrix} = (\boldsymbol{A}_0^T \boldsymbol{P} \boldsymbol{A}_0)^{-1} \boldsymbol{A}_0^T \boldsymbol{P} (\boldsymbol{l} - \boldsymbol{l}_0)$$

Problems

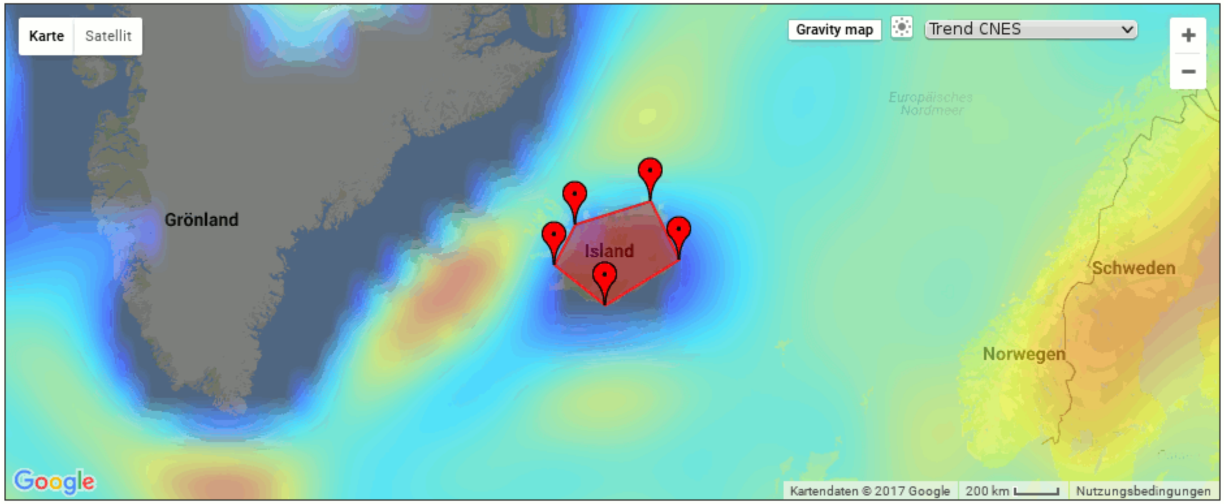
Simplified error model:

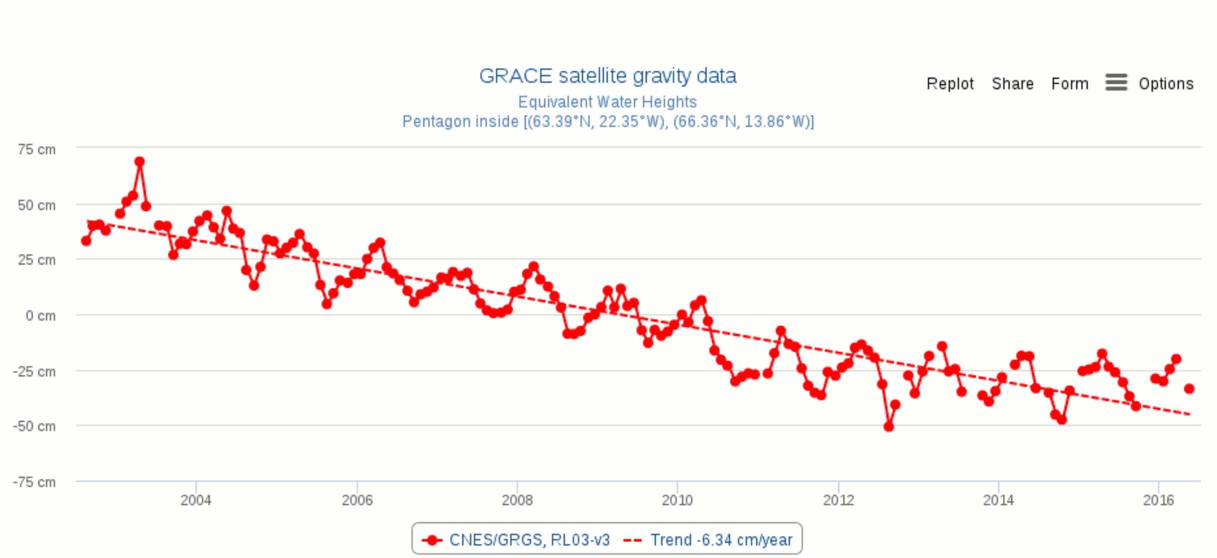
$$C_{ll_0} = \begin{pmatrix} \sigma^2_{\mathrm{GPS}} & & 0 \\ & \ddots & \\ 0 & & \sigma^2_{\mathrm{KBR}} \end{pmatrix}$$

Separate estimation (regularization):

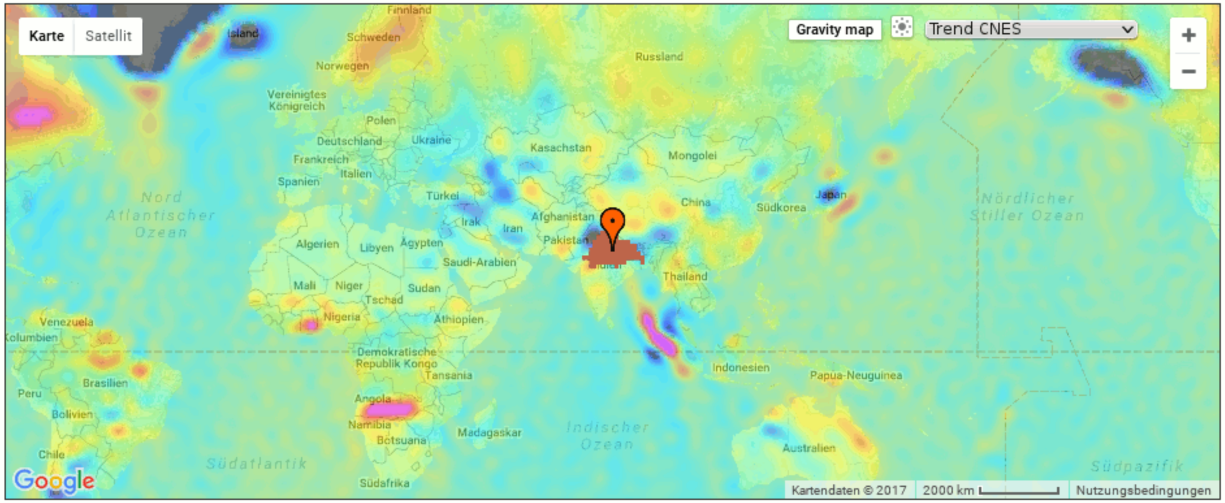
$$\begin{pmatrix} \Delta \boldsymbol{p}_o \\ \Delta \boldsymbol{p}_g \end{pmatrix} = (\boldsymbol{A}_0^T \boldsymbol{P} \boldsymbol{A}_0)^{-1} \boldsymbol{A}_0^T \boldsymbol{P} (\boldsymbol{l} - \boldsymbol{l}_0)$$

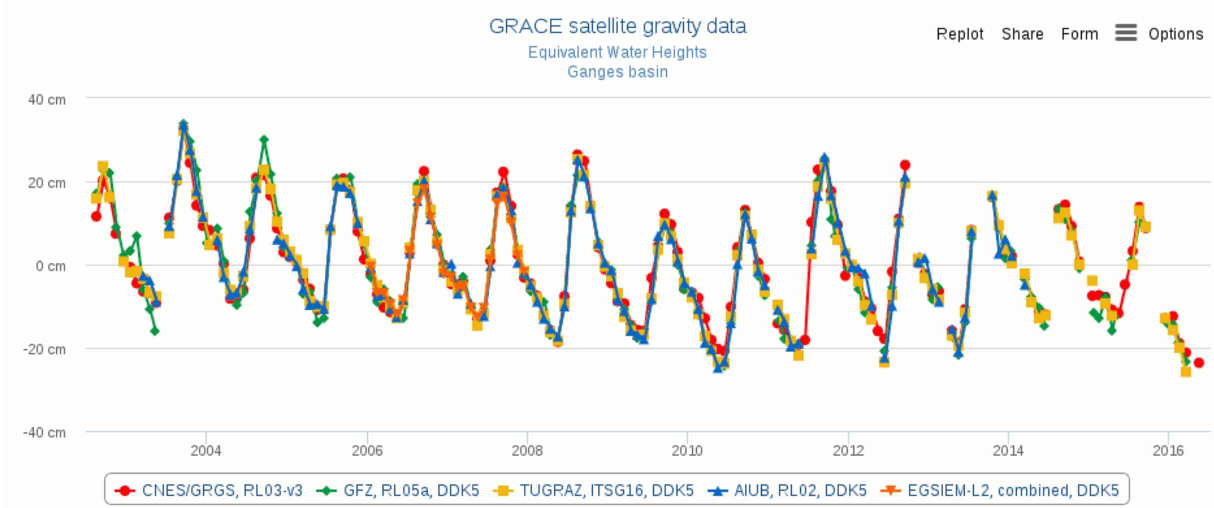
EGSIEM-Plotter (plot.egsiem.eu)



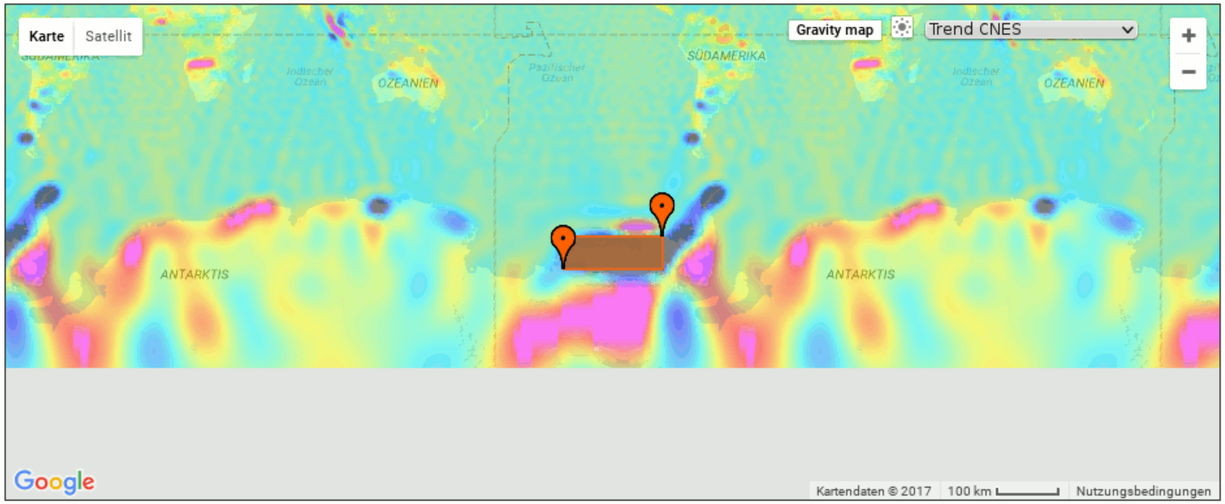


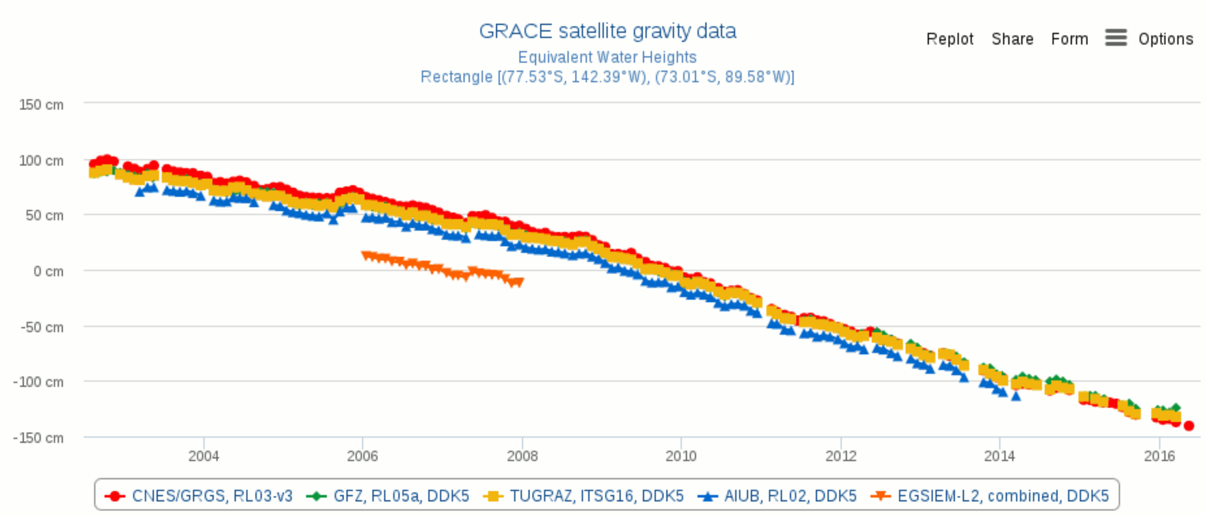
EGSIEM-Plotter (plot.egsiem.eu)



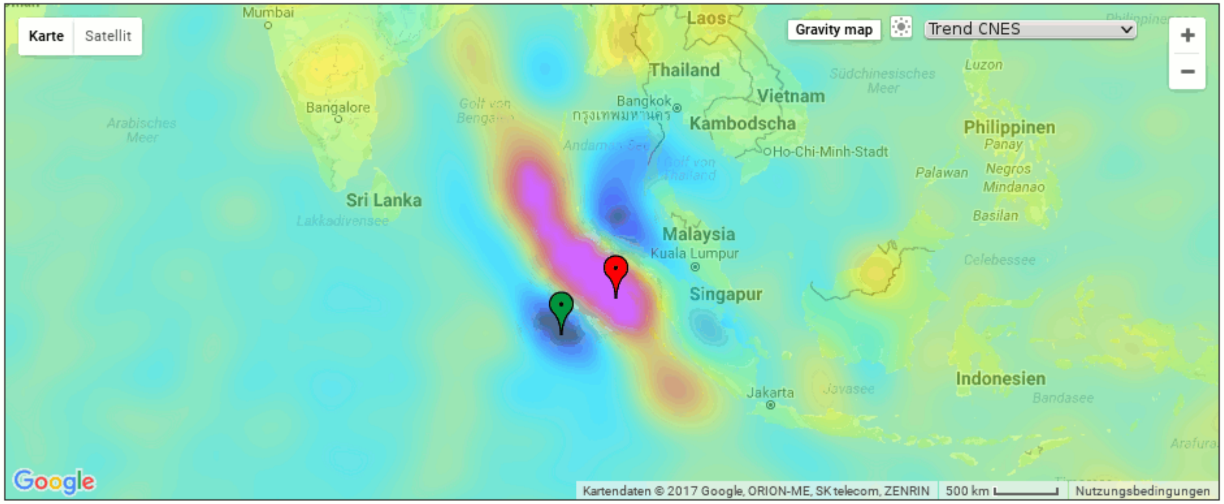


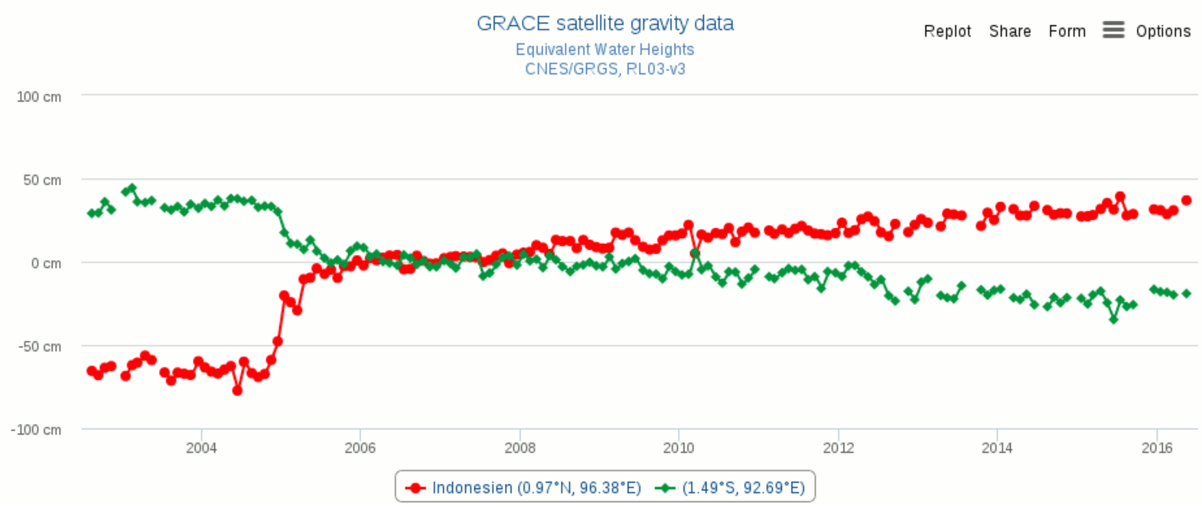
EGSIEM-Plotter (plot.egsiem.eu)



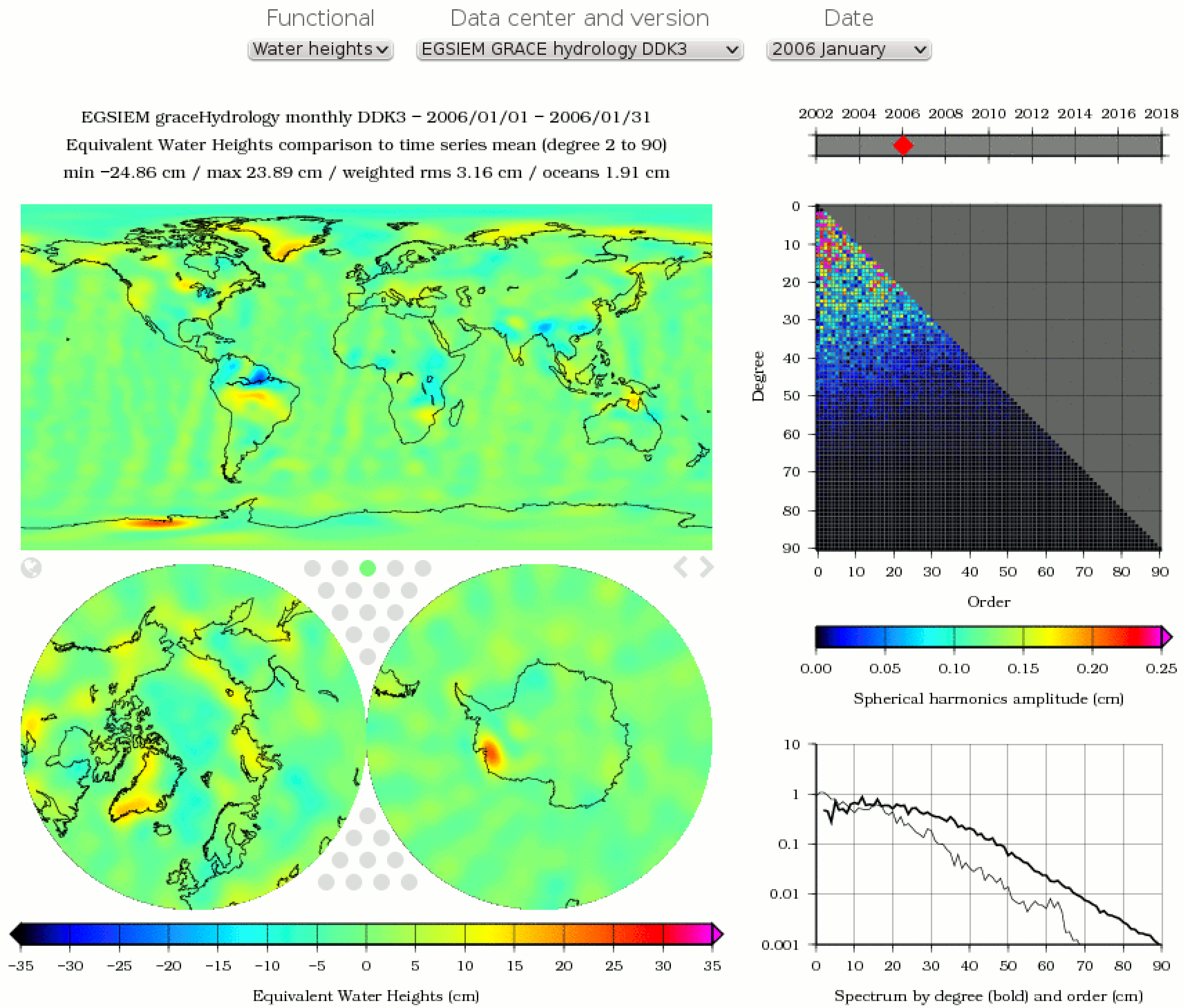


EGSIEM-Plotter (plot.egsiem.eu)





EGSIEM-Plotter: L3-products



Concluding Remarks

- The products of the EGSIEM combination service are available at:
  - SH-coefficients (Level-2): www.icgem.de
  - grids and de-aliasing (Level-3): www.egsiem.eu
- The combination service will be continued as a Combination Center (COST-G) under the umbrella of the International Gravity Field Services (IGFS) of the International Association of Geodesy (IAG).